**Nazwa przedmiotu:**

Theoretical Mechanics II

**Koordynator przedmiotu:**

Prof. Piotr Przybyłowicz, PhD, DSc

**Status przedmiotu:**

Obowiązkowy

**Poziom kształcenia:**

Studia I stopnia

**Program:**

Electric and Hybrid Vehicles Engineering

**Grupa przedmiotów:**

Fizyka i Mechanika

**Kod przedmiotu:**

1150-00000-ISA-0201

**Semestr nominalny:**

3 / rok ak. 2022/2023

**Liczba punktów ECTS:**

5

**Liczba godzin pracy studenta związanych z osiągnięciem efektów uczenia się:**

1) Number of hours with direct contact with the teacher: 65 hrs, including
- lecture: 30 hrs
- practical classes: 30 hrs
- consultations: 5 hrs

2) Student's own work: 60 hrs, including
- ongoing preparation for excercises: 30 hrs
- literature studies and current preparation for tests: 15 hrs
- preparation for the exam: 15 hrs

3) TOTAL number of hours: 125.

**Liczba punktów ECTS na zajęciach wymagających bezpośredniego udziału nauczycieli akademickich:**

2.6 ECTS
Number of hours with direct contact with the teacher: 65 hrs, including
- lecture: 30 hrs
- practical classes: 30 hrs
- consultations: 5 hrs

**Język prowadzenia zajęć:**

angielski

**Liczba punktów ECTS, którą student uzyskuje w ramach zajęć o charakterze praktycznym:**

2.4 ECTS
60 hours of student's work, including
- participation in the practical classes: 30 hrs
- indepedent solving of practical problems at home: 7.5 hrs
- preparation for tests: 7.5 hrs
- preparation for the exam: 15 hrs

**Formy zajęć i ich wymiar w semestrze:**

|  |  |
| --- | --- |
| Wykład:  | 30h |
| Ćwiczenia:  | 30h |
| Laboratorium:  | 0h |
| Projekt:  | 0h |
| Lekcje komputerowe:  | 0h |

**Wymagania wstępne:**

Formal attestation of the course of Theoretical Mechanics I.
Knowledge in linear algebra, differential calculus and fundamentals of functional analysis.

**Limit liczby studentów:**

Brak

**Cel przedmiotu:**

Understanding Mechanics as a knowledge on motion of particles, bodies, mechanisms, machines and vehicles. Formulation of basic laws of motion of bodies and multi-body systems. Description of position and motion of a body in 3D space. Laws of motion of a single body and a mechanism. Understanding phenomena occurring in rotating systems – dynamical reactions in bearings and gyroscopic effect. Understanding the effects of transportation in analysis of relative motion in a moving reference frame. Recognition of effective methods of analytical mechanics, including Lagrange equations. Understanding the phenomenon of impact in Mechanics with practical applications. Understanding the principles of motion of systems with variable mass with applications.

**Treści kształcenia:**

Lecture:

1. Kinematics of a rigid body:
Description of position of a rigid body in space, Euler’s angles. Classification of motions of a rigid body. Velocity and acceleration of points of a body in arbitrary motion, angular velocity and angular acceleration of a body. Particular motions of a body: translation, rotation about a fixed point, plane motion, screw motion.

2. Resultant motion of a particle:
Description of motion of a particle in various reference frames. Transportation and relative motion. Kinematics of resultant motion. Transportation velocity and acceleration. Coriolis acceleration. Dynamics of relative motion of a particle. Relative equilibrium.

3. Dynamics of a rigid body:
Kinetic energy of a body. König’s theorem. Kinetic energy law. Principle of conservation of mechanical energy in case of potential forces. Linear momentum of a body and linear momentum law. Angular momentum of a body and angular momentum law. Dyamics of a body in particular motions: translation, plane motion, precession, rotation about a fixed axis. Dynamic reactions in bearings of a rotor. Gyroscopic effect. Dynamics of a rolling wheel. Dynamics of vehicle traction.

4. Elements of analytical mechanics:
Constraints and generalized coordinates of multiparticle systems. Concept of virtual displacements and virtual work. Principle of virtual work. D’Alembert’s principle. Lagrange equations of motion.

5. Elementary collision theory:
Impact forces. Dynamics of a particle under impact force. Collision of a particle with a massive body. Collision of two particles. Effect of an impact force on a body rotating about a fixed axis. Collision of two bodies in in-plane motions.

6. Dynamics of a particle with variable mass:
Equation of motion. Particular cases of Mieszczerski’s equation. Equation of motion of a rocket. Dynamics of a rocket with uniformly decreasing mass. Fuel consumption law of a rocket with constant acceleration.

Class exercises:

1. Solving kinematic problems of bodies in particular motions – translatory motion, fixed point motion, plane motion, and rotation about fixed axis. Velocities and accelerations of points. Kinematics of a rolling wheel and a planetary gear.

2. Calculations of velocity and acceleration of a particle in a resultant motion.

3. Dynamics of a particle in relative motion analysed in a moving reference frame.

4. Calculations of the kinetic energy of bodies. Application of Koenig’s formula.

5. Dynamics of rigid bodies in particular motions. Dynamics of a rolling wheel, and a vehicle. Dynamics of pure rotation of a body about a fixed axis. Calculations of dynamical reactions in bearings.

6. Analysis of dynamics of bodies in regular precession. Gyroscopic effect.

7. Exercises with Lagrange’s equations of motion.

8. Calculations of impacts and collisions of particles and bodies.

9. Solving equations of motion of particles with variable mass. Motion of a rocket.

**Metody oceny:**

Class exercises: written tests on practical ability to solve simple problems as examples of theory presented within the lecture. Attestation of class exercises.

Lecture: written examination on skills and knowledge concerning the scope of the course.

**Egzamin:**

tak

**Literatura:**

W. Kurnik, Theoretical Mechanics II, Prescript available for students at the Faculty website

**Witryna www przedmiotu:**

Brak

**Uwagi:**

Brak

## Efekty przedmiotowe

### Profil ogólnoakademicki - wiedza

**Efekt 1150-00000-ISA-0201\_W01 :**

The student knows the fundamental notions of classical mechanics such as force, mass, torque, linear and angular velocity and acceleration, momentum, angular momentum, kinetic and potential energy, knows their units, recognizes physical significance.

Weryfikacja:

Written and oral examination

**Powiązane efekty kierunkowe:** K\_W01, K\_W02, K\_W03

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W01, T1A\_W02

**Efekt 1150-00000-ISA-0201\_W02:**

knows basic methods used in mechanics and knows how to choose an appropriate method for a given task.

Weryfikacja:

Exam, written tests in-practical classes, evaluation of homework

**Powiązane efekty kierunkowe:** K\_W01, K\_W02, K\_W03

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W01, T1A\_W02

**Efekt 1150-00000-ISA-0201\_W03:**

knows how to explain practical phenomena related to motion of mechanical systems and mechanisms such as gyroscopic effect, relative equilibrium, resistance to motion in a given medium, rolling resistance, slipping, traction of vehicles, collision of bodies, effect of variable mass on dynamics of a particle.

Weryfikacja:

Exam, written tests in-practical classes, evaluation of homework

**Powiązane efekty kierunkowe:** K\_W01, K\_W02, K\_W03

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W01, T1A\_W02

**Efekt 1150-00000-ISA-0201\_W04:**

knows theoretical fundamentals enabling making use of methods of analytical mechanics to derive equations of balance and dynamics of mechanical systems (principle of virtual work, Lagrange’s equations).

Weryfikacja:

Exam, written tests in-practical classes, evaluation of homework

**Powiązane efekty kierunkowe:** K\_W01, K\_W02, K\_W03

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W01, T1A\_W02

### Profil ogólnoakademicki - umiejętności

**Efekt 1150-00000-ISA-0201\_U01:**

The student can select the proper law of mechanics and incorporate right method for solving the given problem.

Weryfikacja:

Exam, written tests in-practical classes, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0201\_U02:**

can calculate velocity and acceleration of a particle in the resultant motion (including Coriolis’ acceleration).

Weryfikacja:

Exam, written tests in-practical classes, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0201\_U03:**

can solve problems of relative dynamics of particles and can analyze relative equilibrium.

Weryfikacja:

Exam, written tests in-practical classes, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0201\_U04:**

can determine kinetic energy of a rigid body through Koenig’s theorem.

Weryfikacja:

Exam, written tests in-practical classes, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0201\_U05:**

can find dynamical reactions in the supports of rotating shafts.

Weryfikacja:

Exam, written tests in-practical classes, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0201\_U06:**

can derive equations of motion of mechanical systems be applying Lagrange’s formalism of analytical mechanics.

Weryfikacja:

Exam, written tests in-practical classes, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0201\_U07:**

can solve model problems related to collisions between particles and rigid bodies.

Weryfikacja:

Exam, written tests in-practical classes, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0201\_U08:**

can solve dynamical problems of particles with mass varying in time.

Weryfikacja:

Exam, written tests in-practical classes, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03